CAMR WOODCHIP HEATING

Community Industries Ltd.
Woodstock, N.B.
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Project #2014

NB15

Project Manager: Hugh Williams

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

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Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

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Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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D E N I D E R E S P O N S A B I L I T E

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1.0 EXECUTIVE SUMMARY

This project consisted of installing a wood chip burning system at the workshop division of the Canadian Association for the Mentally Retarded in Woodstock, New Brunswick. The heating system is comprised of a large storage bin, a feed conveyor, a gasifier, and a wood-burning furnace. It successfully heats a 372 sq. m. (4,000 sq. ft.) workshop thereby permitting the handicapped workers to do their work in comfort. The entire system displaces 6000 litres of fuel oil per year and has performed very satisfactorily since December, 1982.

1.0 RESUME

Ce project avait pour but d'installer un brûleur de copeaux de bois dans l'atelier de l'Association Canadienne pour la Déficience Mentale à Woodstock au Nouveau-Brunswick. Le système de chauffage comprenait un coffre d'entreposage, un convoyeur d'alimentation, un appareil de chauffage à gaz et une chaudière au chauffage à bois. C'est avec succès que ce système a chauffé un atelier de 372 m. carrés (4,000 pieds carrés) rendant l'atmosphère confortable pour les travailleurs handicapés. Le système au complet déplace 6000 litres de mazout par année et depuis décembre 1982, il démontre une performance des plus satisfaisante.

2.0 INTRODUCTION AND BACKGROUND

In April of 1980. C.A.M.R. began construction of a new facility in Woodstock, N.B. for Community Industries Ltd., its workshop arm. In order to minimize its heating costs, a wood chip burning system was installed. The main components of the system are the chip storage bin, the chip conveyor, the gasifier and the wood-burning furnace. The performance objective of this demonstration project was to heat the 372 sq. m. (4,000 sq. ft.) workshop by a woodchip-burning unit. Some of the alternatives considered were an oil-burning system and electric in-duct heaters. Wood chips were chosen because of their low cost and their local availability. It was estimated that the chip-burning system would displace approximately 6000 litres of oil annually.

3.0 TECHNICAL DESCRIPTION

Essentially, this demonstration project consisted of installing a 89 cu.m. (960 cu.ft.) chip storage bin, a drag chain conveyor, and an auger. These were manufactured locally. A Hunter wood-burning furnace and a Firefly wood gasifier were purchased and installed. The entire arrangement is illustrated in Figure 1.

The heating system was installed in a single story building built in 1981. There is a basement under less than half of the main floor area.

The building walls are made of aluminum and are insulated with 2.5 cm. (one inch) of rigid polystyrene and 15.2 cm. (6 in.) of fiberglas batt insulation. An area of approximately 372 cu. m. (4000 sq. ft.) of the building is heated by the wood chip system and the rest by electric baseboard.

3.1 Gasifier: Principle of Operation

The gasifier itself is a mechanically simple device since it does not use or need motor-driven augers or blowers. Combustion takes place partially in the gasifier and partially in the furnace fire box. The gasifier or preheater, as it is also called, consists of a hopper, a combustion chamber and a refractory tunnel leading to the attached furnace.

In operation, wood chips and/or sawdust in the hopper move downwards by gravity and at the bottom come into contact with a hot U-shaped arch (see Figure 2). Here they are dried and heated and dropped onto a grate where they start to produce gases. They begin to burn in the grate region and refractory tunnel where they mix with additional air. Combustion is completed in the furnace combustion chamber. Daily attention is required for refuelling and ash removal.

The preheater output is controlled thermostatically, either with purely mechanical linkages between the control thermostat and the draft regulating dampers or with electrical controls. As long as the hopper is tightly sealed, any fire there is safely contained. However, the consequence of burnback is likely to be loss of fire in the combustion chamber.

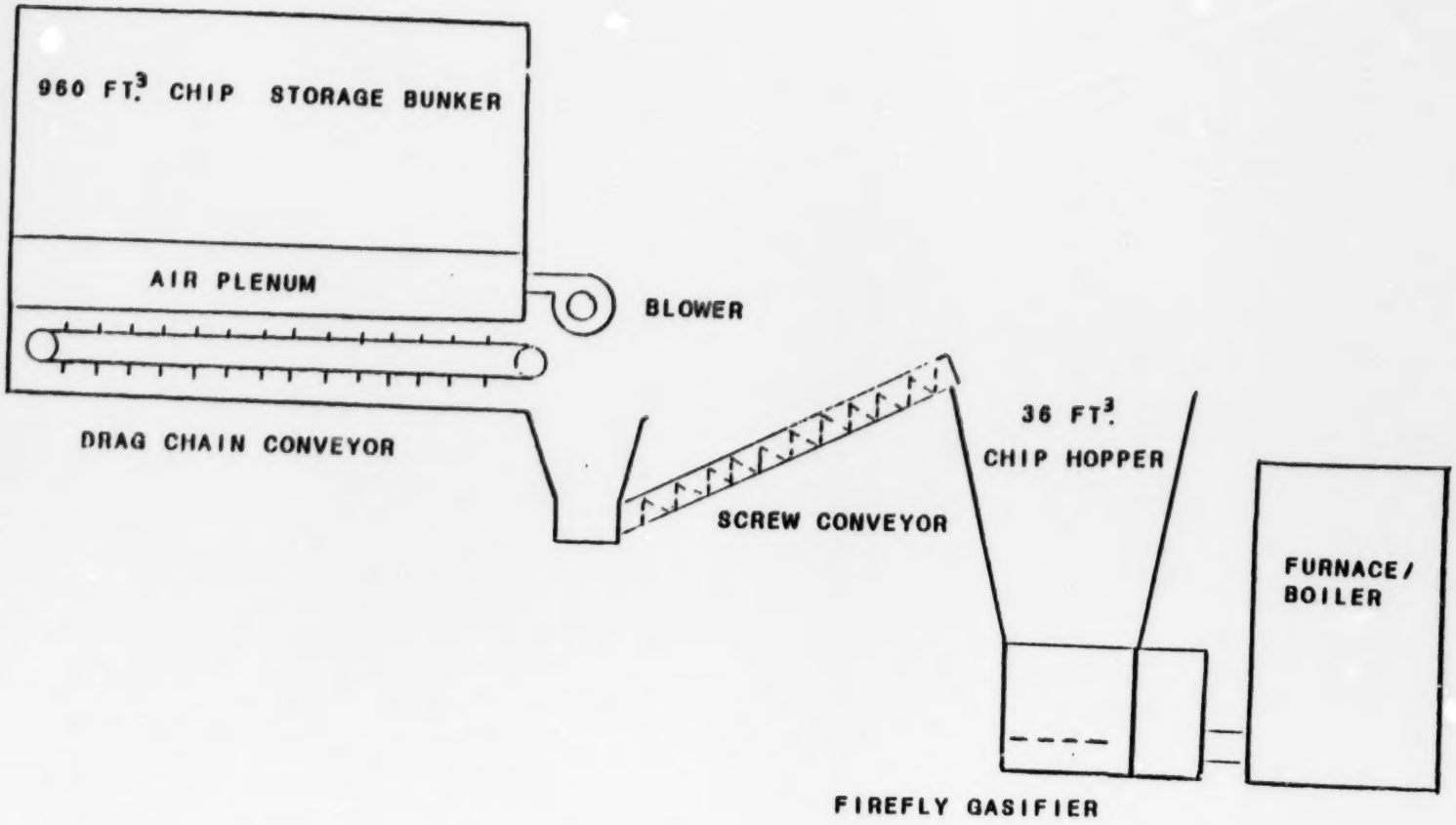
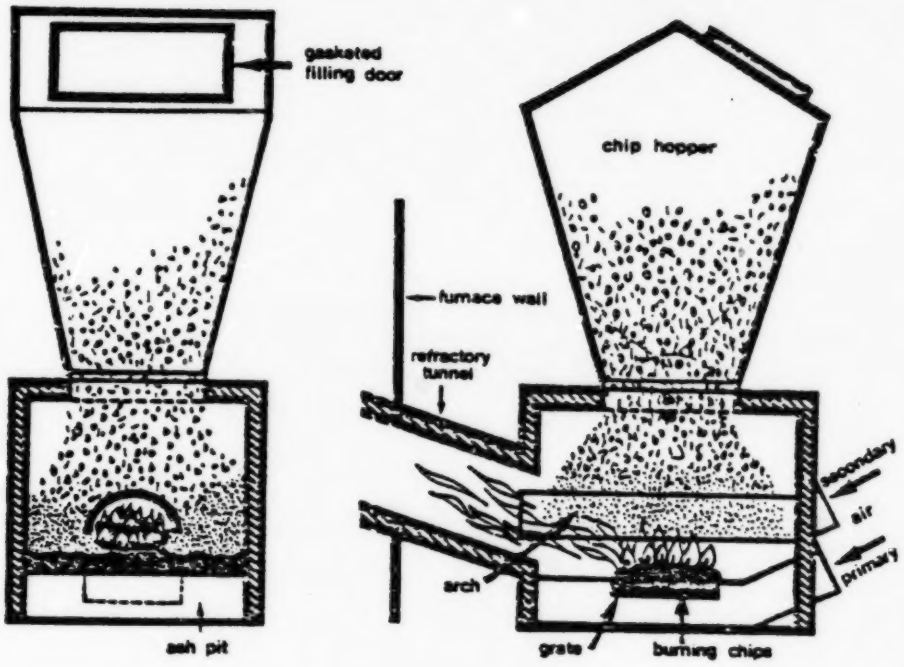


FIGURE 1. WOODCHIP HEATING SYSTEM

Figure 2: The Gasifier



END VIEW

FRONT VIEW

4.0 OBSERVATIONS DURING INSTALLATION AND MONITORING

The heating system began operation in December of 1982. Immediately, a problem was encountered. Chips would lodge in the auger thereby causing the auger to seize, and eventually damage resulted. The problem was solved by reducing the auger diameter from 12.7 cm. (5") to 10.2 cm. (4"), allowing additional clearance inside the 15.2 cm. (6") sleeve, and by increasing the auger speed from 30 RPM to 80 RPM.

The furnace and gasifier tend to operate well in most instances. However, the 83/84 heating season supply of chips (approx. 11.2 tonnes) was fairly green and thus had a high moisture content. This has resulted in the burner not working as well as the previous year, when the chips were much drier. In addition, and as a result of the wet chips, smouldering and a small amount of burnback has occurred in the chip hopper creating creosote. Saturn Industries has recommended checking for pinhole faults in the hopper that might contribute to burnback by allowing combustion air into the hopper, feeding the fire. A tightly closed fuel hopper is recommended to limit the spred of fire in case of burnback, and to control the corrosion effect of the acidic quality of the green fuel. This corrosion eventually causes the pin hole problem which contributes to burnback in the hopper.

It is for these reasons that the furnace is rarely operated at night and consequently resulting in a workshop temperature between 40-45 degrees F in the mornings.

Detailed results of performance monitoring may be found in Appendix A.

5.0 COST/BENEFIT ANALYSIS

The total cost of implementing this heating system was $30,269. This cost, however, includes the cost of repairing the damaged auger and the cost of repairing the furnace which at one point suffered from heat damage. The New Brunswick Energy Secretariat and the Government of Canada, through the Conservation and Renewable Energy Agreement have contributed $22,000 of the total project cost. The remainding $8,269 has been absorbed by Community Industries Ltd. The total amount was broken down into the following:

1.	Capital Cost (including repairs)	$27,819
2.	Consulting Fees	$ 450
3.	Monitoring Equipment	$ 500
4.	Information Transfer	$ 1,500
	TOTAL	$30,269
	CREDA	$22,000
	COMMUNITY INDUSTRIES	$ 8,269

5.1 PAYBACK ANALYSIS

The payback is calculated by first finding the cost of wood consumed during the heating season, then converting this value into equivalent cost of oil consumption. The difference between the two gives the saving achieved by the installation of the new system. The values for wood consumed and heat required by the building are taken from the performance monitoring report of the consultant, Neill and Gunter Ltd., (See Appendix A).

i) COST OF WOOD

Woodchips: 10472 kg (23090 lbs)

10.4 tonnes (11.5 tons) @ $40/ton = $462

Scrapwood: Approx. 10000 kg (22046 lbs)

10.0 tonnes (11.0 tons) = NIL

TOTAL $462

ii) EQUIVALENT OIL

Energy Required: (kg of wood) x (heating value) x (boiler efficiency)

Energy Required: 20472 kg x 16.33 MJ/kg x 0.81

= 270,789 MJ

$$\text{litres of oil} = \frac{270{,}789 \text{ MJ}}{38{,}340 \text{ KJ/l} \times 0.75} = 9393 \text{ litres}$$

Cost of Oil = 9393 litres at $0.378/litres = $3,550

ANNUAL SAVING = $3,550 - $ 462 = $3,088

PAYBACK FOR REPEAT PROJECT (wood vs. oil)

Capital Cost for Repeat Project = $24,000 - $3,000 (cost of oil furnace)

$$\text{PAYBACK} = \frac{\$21,000}{\$3,088} = \underline{\text{6.8 YEARS}}$$

PAYBACK FOR REPEAT PROJECT (wood vs. electric)

Capital Cost for repeat project = $24,000 - $2500 (cost of electric furnace)

$$\text{PAYBACK} = \frac{\$21,500}{\$3088} = \underline{\text{7.0 YEARS}}$$

6.0 CONCLUSIONS AND RECOMMENDATIONS

Since its installation the furnace and gasifier have performed very well in most instances. The 83/84 season supply of overly green chips has caused a decreased burner efficiency as compared to the previous year. The wet chips have also caused some burn-back in the chip hopper creating creosote. Another drawback is that the system lacks CSA approval, making it very difficult to acquire insurance coverage. Therefore, to minimize the danger the furnace is rarely operated at night or left unsupervised for any great period of time.

The chip test and furnace efficiency test performed while burning the dryest chips has produced the following results:

BTU/lb Dry Basis	BTU/lb Wet Basis	% Moisture	Furnace Efficiency %
8276	7067	14.6	81

This indicates a good performance for the gasifier-overfeed technology combined with a hot air furnace. It is felt that the overall efficiency is augmented with drier chips. Burnback and creosote deposits occur because of excessive moisture in the chips. When the hopper is full, moisture tends to rise in the hopper increasing the moisture level in the chips resting in the top half of the hopper. If the burner is operating under load, there is less of a chance for burn-back and creosoting. This means that leaving the unit burning unattended at a low thermostat setting for more than 12 hours is not recommended.

The best way to offset these problems is by making sure the chip supply is as dry as possible. It would help if the chip storage area was vented as well so as to facilitate some drying of the chips.

There has been no problem in obtaining chips for the two heating seasons. The chip system has been used in conjunction with burning of scrapwood from the workshop. The requirements will continue to be approximately 11.2 tonnes of hardwood chips with scrapwood as a supplement.

It can therefore be recommended that this kind of system be used by any small or medium-sized business whose objective is to reduce its heating costs and do so in a safe and practical manner.

APPENDIX A: PERFORMANCE MONITORING REPORT

Neill and Gunter Ltd., a Fredericton consulting firm, performed the monitoring of the system beginning July/83. From July to October, project planning, log sheet preparation and site visits were completed. The actual monitoring began in mid-October, 1983 and was completed March 2, 1984. Neill and Gunter completed performance monitoring and energy consumption while New Brunswick Research and Productivity Council (RPC) provided services for wood chip testing and furnace efficiency testing.

The objectives of the monitoring were to test for:

1) Energy and moisture content of wood chips
2) Furnace efficiency.
3) Energy consumption per degree day per square meter of building area.

Testing for energy and moisture content of the fuel was done at RPC using representative samples. Furnace efficiency was tested using a portable fuel efficiency monitor. The tests consisted of:

flue gas temperature
furnace draft
oxygen content
smoke number

This test was taken with the furnace operating at load and the data were analysed at the RPC Combustion Laboratory.

In calculating the energy consumption, Community Industries kept a record of the monthly volume of chips consumed by the furnace. The consumption was measured by using a specific container for filling the furnace metering bin. The volume of the container was measured. The mass of chips consumed was calculated by multiplying the number of container loads used by the volume of the container and the bulk density of the chips. The gross energy consumption was calculated by multiplying the mass consumed by the "as received" energy content of the chips. The heating degree days for each month of the monitoring period was obtained from the closest meteorological station of Environment Canada in Fredericton.

All the data gathered and the results are listed in the following tables. Other tests performed on similar systems are included in the table to better compare the results. These other furnaces were tested in conjunction with another CREDA project. They are of a simple construction consisting of a wood chip hopper, auger feeder and a fire bowl type wood furnace.

1. Wood Chip Tests

The results of the chip test are summarized in Table 1 below:

Table 1
Wood Chip Tests

Location	Energy Content MJ/	Bulk Density Kg/m3	Moisture %
Steeves	17.32	225.3	11.3
McNair 1	16.29	229.1	16.3
McNair 2	17.11	190.9	12.6
Rundle	16.19	228.2	17.3
Rogers	16.76	233.9	14.2
Community Industries	16.44	250.0	14.6

2. Furnace Combustion Efficiency Test

The results of the furnace combustion efficiency tests are summarized in Table 2 below:

Table 2
Furnace Combustion Efficiency Tests

Location	Smoke #	Draft In H2O	Stack Temp. °C	xO2 %	Fuel Moisture %	Combustion Efficiency %
Steeves	8	0.15	241	14.1	11.3	74
McNair	9	0.30	438	12.1	12.6	61
Rundle	9	0.20	510	10.3	17.3	62
Rogers	8	0.25	375	1.6	14.2	82
Community Industry	7	0.075	484	2.6	16.0	81

Table 3
Gross Energy Consumption

LOCATION: COMMUNITY INDUSTRIES
WOODSTOCK, NEW BRUNSWICK

1 MONTH	2 No. of Fillings	3 Volume Per Filling m /fill	4 (2x3) Volume Consumed m	5 Bulk Density kg/m	6 (4x5) Mass Consumed kg	7 Energy Content MJ/Kg	8 (6x7) Energy Consumed MJ	10 Building Area m	11 Degree Days D	Unit Energy KJ/m / D
Oct. 83	0			250.1		16.44		371.6		
Nov. 83				250.1		16.44		371.6		
Dec. 83	x	N/A	10.19	250.1	2548.5	16.44	41,897.6	371.6	787.4	143.2
Jan. 84	x	N/A	11.33	272.1	3082.9	16.22	50,004.5	371.6	954.8	140.3
Feb. 84	x	N/A	12.13	272.1	3300.6	16.22	53,535.3	371.6	640.9	224.9
Mar. 15/8	x	N/A	5.66	272.1	1540.1	16.22	24,980.2	371.6	444.0	151.4
			39.31		10,472.1		170,417.6		2,827.1	
									Average:	162.2

Energy Consumption

The building details and the gross energy consumed per square meter of ground floor area per heating degree day are summarized in Table 4 below.

Table 4
Unit Energy Consumption

Location	Type of dwelling	Area Consumed m2	Energy KJ/m2/°D	Period
Steeves	2-storey R-12 walls R-30 ceiling	78.0	407.7	Nov 1/83 to Feb 29/84
McNair	1-1/2 storey R-12 walls R-30 ceiling	95.1	No Report	
Rundle	2-storey R-0 walls	80.4	785.4	Nov 18/83 to Jan 20/84
Rogers	2-storey + 1-1/2 storey R-20 walls R-20 ceiling	85.8	472.1	Jan 26/84 to Feb 10/84
Community	1-storey commercial R-30 walls R-20 ceiling	371.6	162.2	Dec 1/83 to Mar 15/84

Only L. Steeves has supplied complete log sheets for fuel consumption. Three of the others supplied data which was either incomplete or poorly recorded and consequently required considerable interpretation. C. McNair has not supplied any information to date.

Table 5
Furnace Data

LOCATION	TYPE	MANUFACTURER	MODEL	RATED CAPACITY BTU/Hr.
Steeves	Hot Air	Kerr	Scotsman DB101	
McNair	Hot Water	New Yorker		65,000
Rundle	Hot Air	Olson	Duomatic CWF	
Rogers	Hot Air	New Mac	WB-1W	80-100,000
Community Industries	Hot Air	Valley Comfort	RB4	200,000